Use of Geophysical Methods, Investigation by Drilling, and Remediation of Highway T Subsidence, Macon County, Missouri

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Today, what we'll be looking at:

- Geophysical representation of abandoned underground mining
- Drilling methods used by the State and its Contractors
- Grouting methods
- Perceived efficacy of the method used.

Route T, Macon County, Missouri

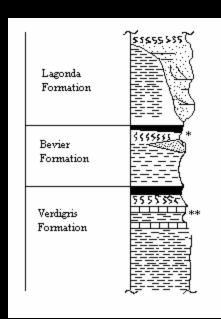
- A secondary route in Missouri between US Highway 63 at the community of Excello and the community of College Mound, Missouri.
- Route bisects what used to be known as the 'Ardmore Mining District', with both surface mining and underground mining present.

approximately 1.2 miles long



- Area is undermined by the old Kansas and Texas Coal Company Mine No. 57, abandoned in 1903.
- Route T over the mines has been a maintenance headache for 20 years.

Stratigraphic Section of the Area



- composed of shale, siltstone, and sandstone, coal; underclay marks the top of the formation; thickness varies from 35-95 feet.
- consists of four distinct beds: a mottled shale at base, an earthy limestone, a dark gray shale, and the Bevier coal (*)at top.
- consists of a gray mudstone, a black, fissile shale, the Ardmore member (***) which is a limestone or a succession of limestone and interbedded shale, the Wheeler coal underclay and the Wheeler coal seam.
- Three Formations in the area, two coal seams which merged and became one: the Bevier-Wheeler coal seam.
- Each Formation represents a separate depositional cycle, or cyclothem.

'warning signals' for coal mine collapse.



- Separation cracking along highway lanes, perpendicular to centerline.
- Depressions in adjacent properties and along right of way.
- "Swallow holes"

Primary Focus is to insure Public Safety and Protect Transportation Route

Route T, though originally intended as a "farm-to-market" route, serves additional purpose now for trucks transporting aggregate from west of Huntsville, refuse haulers with a final destination of the Moberly landfill, and a connector route for residents of College Mound, Excello, Bevier, Macon, and Moberly.

First Investigational Priority Drilling to Determine Immediate Collapse Potential



- Depressional Areas Along Right of Way and in lane.
- Areas exhibiting tension cracking
- Areas with adjacent "swallow holes" or history of maintenance trouble or collapse.

What was found in the first round of drilling?

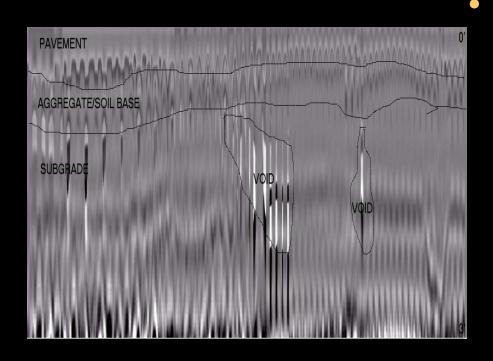


- Stratigraphy established beyond doubt.
- Roof materials of the mine were not of sufficient strength to support truck traffic over voids.
- Voids were found.

Second Phase of Investigation

- Determine potential locations of potential voids using geophysical means.
 - Ground Penetrating Radar (GPR) useful only for uppermost 10' due to high clay content of shales
 - Dipole-Dipole Resistivity
- Additional supplemental drilling over likely locations of disturbance and voids.

Ground Penetrating Radar (GPR)



Ground Penetrating
Radar is a useful tool
for the identification
of subgrade, subsurface voids
PROVIDED the depth
is shallow if clayey
soil conditions are
present.

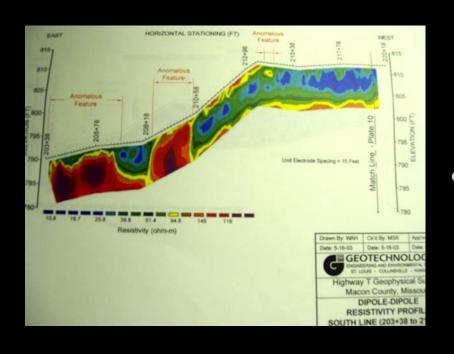
Subgrade GPR image from Interstate 170, St. Louis County, using Vermeer Interragator portable GPR unit

Ground Penetrating Radar (GPR) traverse of Route T



- Work Performed by Geotechnology, Inc. of St. Louis, Missouri.
- Largely ineffectual at depth due to high clay content of Lagonda
 Formation shales

Dipole-Dipole Resistivity of Route T



- Work also performed by Geotechnology, Inc.
- Better resolution of potential mine void areas.

Second Round of Drilling



- Drilling over potential void areas in most cases where indicated by resistivity.
- Holes cased with 4" ID PVC pipe for future grouting.

Missouri DNR's Land Reclamation Program Involvement

- After 2nd round of drilling and letter to Land Reclamation Program from GSRAD, emergency funds were requested from the US Dol Office of Surface Mining.
- This request was approved due to the truck traffic, the DNR request, and cooperation between all parties.

Grouting Began Feb. 2004



Grouting Operations were overseen at this point by MoDOT **District 2 (Macon** District) personnel, **DNR's Abandoned** Mine Land Section, and Missouri **Geological Survey** and Resource **Assessment Division.**



- Void locations identified from drilling were targets of grouting
- Mixture of concrete and flowable fill was used.



 A grout pump similar to a Mudjack machine was used; the PVC pipe in the foreground was inserted in the drilled hole to pump the grout.



• The specific brand of flowable fill used was something called "Fritz-Pak"; Two to three bags were dumped in every hopper of mixed concrete for fast set times.



Additional holes were pattern drilled into the mine; where voids were encountered, grout was pumped in until the void was filled; a total of 1500 cubic yards was pumped into holes to support the road.

Lessons Learned

- Geophysical technique or core drilling alone won't solve the void location and delineation problem; both must be used cooperatively to solve problems.
- GPR was unsuitable for this project, because it only illustrated the top ten feet; we needed deeper delineations.
- Dipole-dipole resistivity gave good correlation with voids as determined by drilling.

Lessons Learned

 A qualified geologist or geotechnical engineer should be in charge of the entire operation; all concerned parties should work cooperatively to solve the problem and address all public safety concerns before, during and after the project.

Acknowledgements

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